

What Is Claimed Is:

1           1. A rotor for use in an electrical  
2 machine, said rotor having an axis of rotation and  
3 comprising:  
4           a first pole piece having a plurality of  
5 axially-extending first pole fingers and a first inner  
6 rotor portion;  
7           a second pole piece having a plurality of  
8 axially-extending second pole fingers and a second  
9 inner rotor portion;  
10          a field coil magnetically coupled with said  
11 first pole piece and said second pole piece which when  
12 energized magnetizes said first pole fingers and said  
13 second pole fingers such that said first pole fingers  
14 have a north magnetic polarity and said second pole  
15 fingers have a south magnetic polarity;  
16          a plurality of permanent magnets having a  
17 first set of permanent magnets and a second set of  
18 permanent magnets;  
19          one of said first set of permanent magnets  
20 disposed between one of said plurality of first pole  
21 fingers and one of said plurality of second pole  
22 fingers, said one of said first set of permanent  
23 magnets having a first radially-inward surface, a first  
24 radially-outward surface, a first side surface and a  
25 second side surface, wherein said first side surface is  
26 adjacent to one of said plurality of first pole fingers  
27 and substantially extends the length of one of said  
28 plurality of first pole fingers, wherein said second  
29 surface is adjacent to one of said plurality of second  
30 pole fingers and substantially extends the length of  
31 one of said plurality of second pole fingers;

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32 one of said second set of permanent magnets  
33 disposed between one of said plurality of first pole  
34 fingers and the other of said two adjacent said  
35 plurality of second pole fingers and having a second  
36 radially-inward surface, a second radially-outward  
37 surface, a third side surface and a fourth side  
38 surface, wherein said third side surface is adjacent to  
39 said first pole finger and substantially extends the  
40 length of said first pole finger, wherein said fourth  
41 side surface is adjacent to said other of said two  
42 adjacent said plurality of second pole fingers and  
43 substantially extends the length of said other of said  
44 two adjacent said plurality of second pole fingers; and  
45 wherein said first radially-outward surface  
46 and said first side surface have a north magnetic  
47 polarity and wherein said second radially-outward  
48 surface and said fourth side surface have a south  
49 magnetic polarity.

1 2. An electrical machine having a rotor as  
2 defined in claim 1.

1 3. An electrical machine having a rotor  
2 according to claim 2, wherein said electrical machine  
3 is an alternator.

1 4. The electrical machine having a rotor as  
2 in claim 2, wherein said plurality of permanent magnets  
3 produces permanent magnetic flux from one of said first  
4 set of permanent magnets to each of said second set of  
5 permanent magnets located adjacent to said one of said  
6 first set of permanent magnets such that said permanent

7 magnet flux creates a flux linkage in a stator winding  
8 on the electrical machine.

1           5. The electrical machine of claim 2,  
2 wherein said plurality of permanent magnets produces  
3 permanent magnetic flux from said one of said first set  
4 of permanent magnets to one of said second set of  
5 permanent magnets located adjacent to said one of said  
6 plurality of permanent magnets such that said magnetic  
7 flux acts in opposition to a field current flux in said  
8 first pole piece and said second pole piece, whereby  
9 said flux linkage is increased in a stator winding of  
10 the electrical machine, thereby increasing output power  
11 from said stator winding of the electrical machine.

1           6. The electrical machine of claim 2,  
2 wherein said plurality of permanent magnets produces  
3 permanent magnetic flux from one of said first set of  
4 permanent magnets to one of said second set of  
5 permanent magnets located adjacent to said one of said  
6 plurality of permanent magnets such that said permanent  
7 magnet flux creates a flux linkage in a stator winding  
8 on the electrical machine; and wherein said magnetic  
9 flux acts in opposition to a field current flux in said  
10 first pole piece and said second pole piece, whereby  
11 said flux linkage is increased in a stator winding of  
12 the electrical machine, thereby increasing output power  
13 from said stator winding of the electrical machine.

1           7. The electrical machine of claim 1,  
2 wherein each of said plurality of permanent magnets is  
3 affixed to the rotor between one of said plurality of

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4 first pole fingers and one of said plurality of second  
5 pole fingers.

1 8. A rotor for use in an electrical  
2 machine, said rotor having an axis of rotation and  
3 comprising:

4 a plurality of axially-extending pole pieces  
5 having an inner rotor portion;

6 a plurality of rotor coils, one of said  
7 plurality of rotor coils magnetically coupled with one  
8 of said plurality of axially-extending pole pieces  
9 which when energized magnetizes said one of said  
10 plurality of axially-extending pole pieces such that  
11 each adjacent one of said plurality of axially-  
12 extending pole piece has an opposite magnetic polarity;

13 a plurality of permanent magnets having a  
14 first set of permanent magnets and a second set of  
15 permanent magnets;

16 one of said first set of permanent magnets  
17 disposed between a first adjacent pair of said  
18 plurality of axially-extending pole pieces and having  
19 a first radially-inward surface, a first radially-  
20 outward surface, a first side surface and a second side  
21 surface, wherein said first side surface is adjacent to  
22 one of said first adjacent pair of pole pieces and  
23 extends the length of one of said first adjacent pair  
24 of pole pieces, wherein said second surface is adjacent  
25 to the other of said first adjacent pair of pole pieces  
26 and extends the length of other of said first adjacent  
27 pair of pole pieces;

28 one of said second set of permanent magnets  
29 disposed between a second adjacent pair of said  
30 plurality of axially-extending pole pieces and having

31 a second radially-inward surface, a second radially-  
32 outward surface, a third side surface and a fourth side  
33 surface, wherein said third side surface is adjacent to  
34 one of said second adjacent pair of axially-extending  
35 pole pieces and extends the length of one of said  
36 second adjacent pair of axially-extending pole pieces,  
37 wherein said fourth surface is adjacent to the other of  
38 said second adjacent pair of axially-extending pole  
39 pieces and extends the length of said other of said  
40 second adjacent pair of axially-extending pieces;

41 wherein said other of said first adjacent  
42 pair of said plurality of axially-extending pole pieces  
43 and said other of said second adjacent pair of said  
44 plurality of axially-extending pole pieces have the  
45 same magnetic polarity ; and

46 wherein said first radially-outward surface  
47 and said first side surface have a north magnetic  
48 polarity and wherein said second radially-outward  
49 surface and said fourth side surface have a south  
50 magnetic polarity.

1 9. An electrical machine having a rotor as  
2 defined in claim 8.

1 10. An electrical machine having a rotor  
2 according to claim 9, wherein said electrical machine  
3 is an alternator.

1 11. The electrical machine having a rotor as  
2 in claim 9, wherein said plurality of permanent magnets  
3 produces permanent magnetic flux from said first set of  
4 permanent magnets to one of said second set of  
5 permanent magnets located adjacent to said one of said

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6 first set of permanent magnets such that said permanent  
7 magnet flux creates a flux linkage in a stator winding  
8 on the electrical machine.

1 12. The electrical machine of claim 9,  
2 wherein said plurality of permanent magnets produces  
3 permanent magnetic flux from one of said first set of  
4 permanent magnets to one of said second set of  
5 permanent magnets located adjacent to said one of said  
6 first set of permanent magnets such that said magnetic  
7 flux acts in opposition to a field current flux in said  
8 plurality of axially-extending pole pieces, whereby a  
9 flux linkage is increased in a stator winding of the  
10 electrical machine, thereby increasing output power  
11 from said stator winding on the electrical machine.

1 13. The electrical machine of claim 9,  
2 wherein said plurality of permanent magnets produces  
3 permanent magnetic flux from one of said first set of  
4 permanent magnets to one of said second set of  
5 permanent magnets located adjacent to said one of said  
6 first set of permanent magnets such that said permanent  
7 magnet flux creates a flux linkage in a stator winding  
8 on the electrical machine, thereby increasing output  
9 power from a stator winding on the electrical machine;  
10 and wherein said magnetic flux acts in opposition to a  
11 field current flux in said plurality of axially-  
12 extending pole pieces, whereby said flux linkage is  
13 increased in said stator winding of the electrical  
14 machine, thereby increasing output power from said  
15 stator winding on the electrical machine.

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1           14. The electrical machine of claim 8,  
2 wherein each of said plurality of permanent magnets is  
3 affixed to the rotor between an adjacent pair of said  
4 axially-extending pole pieces.

1           15. A method of increasing rotor flux and  
2 power output in a hybrid permanent magnet synchronous  
3 machine, the method comprising the step of:  
4           generating a permanent magnet flux  
5 circulating from one of a first set of permanent  
6 magnets through a stator to one of a second set of  
7 permanent magnets, said permanent magnet flux  
8 continuing from said one of said second set of  
9 permanent magnets through one of a first set of poles,  
10 an inner rotor portion, and one of a second set of  
11 poles, thereby returning to said one of said first set  
12 of permanent magnets, wherein said permanent magnet  
13 flux in said first set of poles and said second set of  
14 poles and said inner rotor portion acts in opposition  
15 to a field current magnetic flux generated when a field  
16 winding is excited with current.

1           16. A method according to claim 15, wherein  
2 the step of generating a permanent magnet flux  
3 comprises the steps of:  
4           disposing a first permanent magnet having a  
5 first radially-inward surface, a first radially-outward  
6 surface, a first side surface and a second side surface  
7 between one of said first set of poles and an adjacent  
8 one of said second set of poles, wherein said first  
9 radially-outward surface and said first side surface  
10 have a first magnetic polarity; and

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11 disposing a second permanent magnet having a  
12 second radially-inward surface, a second radially-  
13 outward surface, a third side surface and a fourth side  
14 surface between said one of said first set of poles and  
15 the other adjacent one of said second set of poles,  
16 wherein said first side surface substantially extends  
17 the length of said one of said first set of poles and  
18 is located adjacent to said adjacent one of said first  
19 set of poles and wherein said third side surface  
20 substantially extends the length of said one of said  
21 first poles and is located adjacent to said adjacent  
22 one of said first poles, wherein said second radially-  
23 outward surface and said fourth side surface have a  
24 second magnetic polarity, where said first magnetic  
25 polarity and said second magnetic polarity are opposite  
26 magnetic polarities.

1 17. The method according to claim 15,  
2 wherein the step of generating a permanent magnet flux  
3 comprises the step of generating a permanent magnet  
4 flux circulating from one of a first set of permanent  
5 magnets through a stator to one of a second set of  
6 permanent magnets, said permanent magnet flux  
7 continuing from said one of said second set of  
8 permanent magnets through one of a first set of poles,  
9 an inner rotor portion, and one of a second set of  
10 poles, thereby returning to said one of said first set  
11 of permanent magnets, wherein said permanent magnet  
12 flux said first set of poles and said second set of  
13 poles and said inner rotor portion acts in opposition  
14 to a field current magnetic flux generated when a field  
15 coil is excited with current.



1           18. The method according to claim 15,  
2 wherein the step of generating a permanent magnet flux  
3 comprises the step of generating a permanent magnet  
4 flux circulating from one of a first set of permanent  
5 magnets through a stator to one of a second set of  
6 permanent magnets, said permanent magnet flux  
7 continuing from said one of said second set of  
8 permanent magnets through one of a first set of poles,  
9 an inner rotor portion, and one of a second set of  
10 poles, thereby returning to said one of said first set  
11 of permanent magnets, wherein said permanent magnet  
12 flux in said first set of poles and said second set of  
13 poles and said inner portion acts in opposition to a  
14 field current magnetic flux generated when a rotor coil  
15 is excited with current.